Increased dangers to Caribbean marine ecosystems

Cruise ship anchors and intensified tourism threaten reefs

> No person shall cut, carve, injure, mutilate, remove, displace, or break off any underwater growth or formation. Nor shall any person dig in the bottom, or in any other way injure or impair the natural beauty of the underwater scene. No rope, wire, or other contrivance...shall be attached to any coral, rock, or other underwater formation....No watercraft shall be operated in such a manner, nor shall anchors or any other mooring device be cast or dragged or placed, so as to strike or otherwise cause damage to any underwater features.
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> —From the US Code of Federal Regulations for Virgin Islands National Park

On the morning of 9 October 1988, the 440-foot cruise ship *Wind Spirit* slid majestically into Francis Bay off St. John, one of the US Virgin Islands, and dropped its giant anchor on a coral reef. To the tourists aboard the *Wind Spirit*, the scene provided an idyllic panorama commonplace in the Caribbean: pastel blue waters giving way to lush green slopes on surrounding islands and cays. But to employees of the Virgin Islands National Park (VINP), it was a scene of destruction.

The anchor and the heavy links of its chain tore through part of the Johnson's Reef region and "virtually destroyed" a 300-square-yard area of coral, as Caroline S. Rogers, research director at VINP, later put it. The incident occurred within the boundaries of the park, which is a United Nations Biosphere Reserve. When the cloud of underwater sediment cleared, scuba divers with the National Park Service discovered that "corals and other reef organisms were pulverized, overturned and ripped from their bases," says Rogers.

Such incidents of severe damage to coral reefs are on the rise—in and out of protected areas, say Rogers and several marine biologists who have been watching the demise of coral reefs around the tropics. Their degradation is important because, these biologists say, coral reefs are to the marine world what tropical forests are to life on land. Coral reefs support the most diverse ecosystems in the oceans.

"Urgent action is needed to prevent serious coral loss," says Stephen H. Smith, a marine ecologist at Environmental Technologies International, a Honolulu-based firm that specializes in environmental assessments and other ecological studies. Smith, who has studied reef damage in many parts of the world, says, "Anchor-damaged reefs may never recover. And if they do, it will be a slow process, in most cases more than 50 years."

The anchor damage from an expanding flotilla of cruise ships is the most recent and dramatic example of a larger issue that marine scientists and national park officials have been worrying about for some time: how to balance the adverse effects of marine-based tourism with marine resource protection in the Caribbean. Adverse effects include damage from small-boat anchors, boat groundings, and snorkelers and scuba divers, biologists say. And all of these tourist problems are added atop erosion, pesticide runoff, sewage, and other stresses that have increased due to development of the islands, as well as oil spills, overfishing, and natural reef-bashers such as hurricanes.

"We're seeing a general degradation of seagrass, mangrove, and coral reef habitats from a variety of possible influences," says Billy Causey, a marine biologist and project manager of the Florida Keys National Marine Sanctuary. "It's happening in the Florida Keys and throughout the Caribbean, and for that matter around the globe."

The anchor issue

Anchor damage is one of the most serious threats to marine resources in the Caribbean, some biologists say. Reef destruction caused by small-boat anchors and groundings has been documented by scientists at least since the 1970s.

But recently, marine biologists became concerned about the growing number of medium-sized and large cruise ships, especially from North America, which are filled with tourists flocking to the Caribbean. Many of these ships are capable of entering shallow, environmentally sensitive areas and inflicting serious damage to coral reefs with their multiton anchors and anchor chains.

The growth of Caribbean cruising is well-documented. The Caribbean is the number-one cruise ship destination in the world, according to Cruise Lines International Association (CLIA), an industry marketing group based in New York City. Cruise lines are starting or expanding their Caribbean fleets to accommodate a continually growing number of passengers.

According to one estimate by researchers at the Caribbean Natural Resources Institute, on St. Croix, the number of people who traveled to the Caribbean on cruise ships between

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1981 and 1987 jumped from 3.4 million a year to 5.6 million. From 1982 to 1987, the number of cruise ships touring the region rose from 35 to 82.

More than 160 cruise ships could ply the Caribbean by 1995, according to the researchers' estimates. CLIA officials say the reasons for the boom include the Caribbean's calm waters, warm temperatures, rich culture, and proximity to ports served by major airlines.

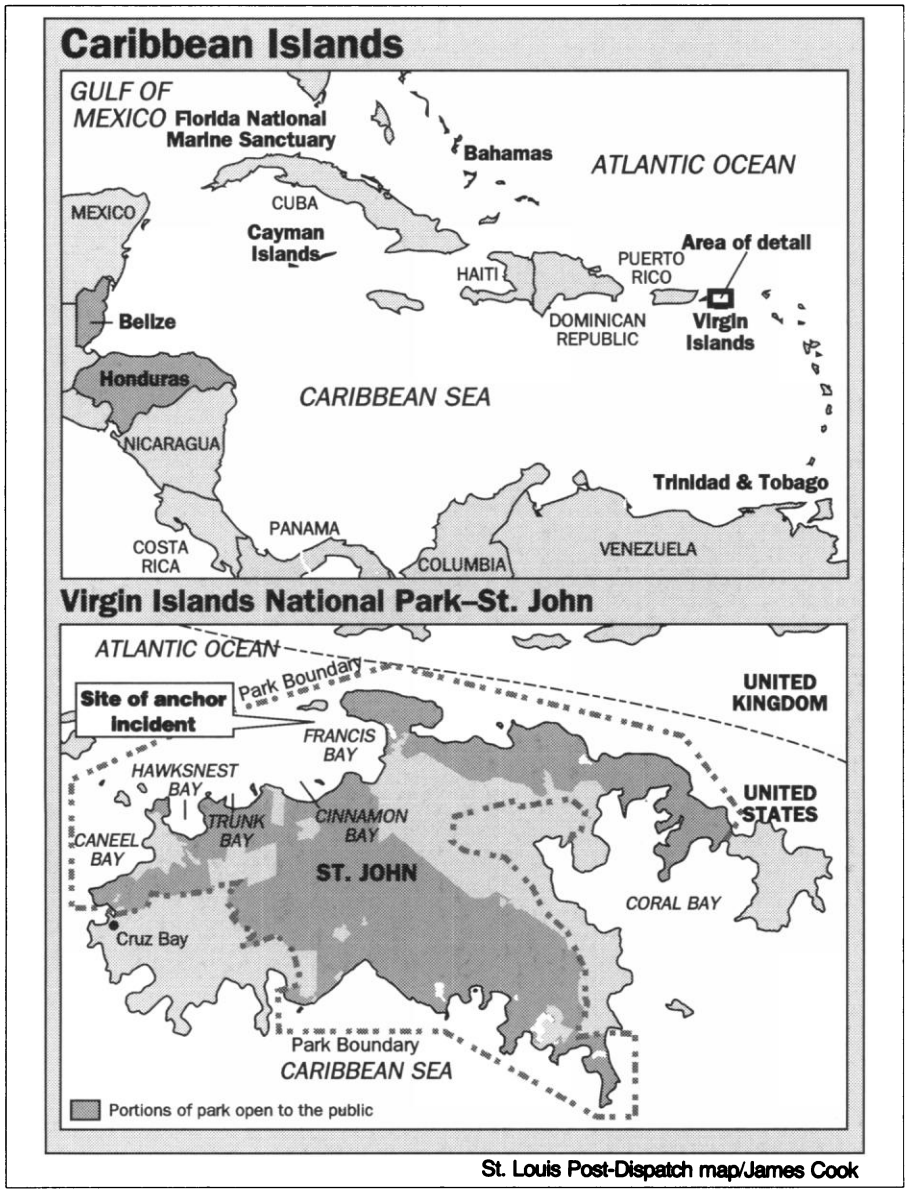
Few biologists have actually witnessed anchor damage in progress. Marine ecologist Smith had a rare opportunity to do so when he went underwater to study cruise ship anchor damage as a researcher with the Grand Cayman Island Natural Resources Laboratory in the 1980s.

The Cayman Islands have largely escaped the destructive effects of coral harvesting, mining, dynamite and bleach fishing, and industrial projects, Smith says. But with tourism generating most of the island's foreign exchange, cruise ship anchors have taken a heavy toll.

With colleague Scott Slaybaugh, Smith scuba-dived beneath several vessels that anchored on different reefs along Grand Cayman, including six cruise ships, four live-aboard scuba-diving cruisers, a US Navy frigate, and several smaller boats ranging in length up to 15 meters. One of the most revealing dives was under the cruise ship *MV Starward* in February 1985, when it anchored on a previously undisturbed section of coral at Spotts Reef on the south side of the island. The 525-foot *Starward*, carrying 788 passengers, had dropped its five-ton anchor on a coral head in 17 meters of water. Dozens of 100-pound chain links stretched approximately 150 meters across the reef before sweeping up to the ship.

The anchor alone crushed all coral formations within 3 meters of it, Smith says. The day was calm, but as the anchor chain swayed slowly with the ship, it crushed, snapped, or twisted any coral in its path. Near the anchor, the path of destruction was only 1 or 2 meters wide, but approximately 70

Diver with the five-ton anchor of the MV Starward off the Cayman Islands in 1985. Photo: Stephen H. Smith.



St. Louis Post-Dispatch map/James Cook

meters from the anchor the path was 50 meters wide. At this distance, the chain dragged across the face of a deeper-sloping fore-reef, the reef's vertical step-like rise. The chain tore 8-meter-wide coral heads from their bases and sent them tumbling down the fore-reef. The effect was akin to an avalanche.

"Clouds of pulverized coral billowed into the water column and settled like snow," Smith says. "Many corals that were not completely crushed had all their living tissue scraped off." The anchor and chain "totally destroyed" a section of reef that measured more than 2100 square meters (equal to half a football field). Another area of the reef half that size had its coral fragmented to a height of one inch; it later died. The sediment "severely stressed" other nearby reefs, Smith says.

"The extent of the damage was not unusual," Smith says. "It was a calm day with no swell or current. If there had been a strong wind that day, and the ship was moving more, then the damage would have been greater."

Several months later, a survey revealed that 62% of the coral cover on the deep terrace fore-reef and 93% of the coral on the deep terrace reef (the flat portion of the reef) closer to the anchor had been destroyed, either from the direct assault of the anchor and chain or from smothering. The fish population in the area appeared to have thinned significantly during the two-year period in which Smith continued to survey the reef.

Recovery of the coral—much less the reef community—can vary from place to place and depends greatly on the type of destruction. For example, studies by Eugene A. Shinn of the US Geological Survey in St. Petersburg, Florida, have shown that coral in the Florida Keys recovered completely within five years of Hurricane Donna in 1960.

Scientists attributed the successful return to the fast growth rate of the dominant staghorn coral. Also, the storm had left some coral fragments unburied and alive and had uncovered large areas, making new growth possible.

However, other studies by Robert Endean at the University of Queensland, Australia, have shown that reefs destroyed by flooding, dredging, or toxic volcanic water had not recovered after 30 years or more. There are few long-term studies on anchor damage.

The succession of coral communities depends much on which local species of coral grow faster or are better competitors. In some cases, macroalgae may be able to take over after the reef is seriously disrupted. The impact of such changes, reaching up through fish communities, can be profound for the local diet and for the tourist industry, Smith says. He warns that the fine, unstable substrate created by the action of anchors and chains would severely inhibit recolonization.

Growth rates of the Cayman Islands' corals, which have not been studied, are probably similar to those of corals in other Caribbean and west-

ern Atlantic regions, Smith says. He estimates that it will take centuries for star and brain corals to grow to the size (greater than two meters in diameter) common at Spotts Reef before anchor damage.

Reef destruction by anchor chains similar to that described by Smith has been reported off Anguilla, the Bahamas, Belize, Bermuda, Bonaire, the British and US Virgin Islands, Honduras, the Philippines, and Trinidad. Rarely is anything done to stop cruise ships from destroying reefs.

The *Wind Spirit* case

Most of the time, like a tree falling in a remote forest, no one other than the cruise ship captain knows when an anchor crashes onto a reef, only to ascend a few hours later as the ship sails off to the next island. Often the captain is not aware of the damage. And even when damage is discovered by investigators, determining the exact cause is often difficult. Further still, few legal precedents exist on which redress for natural resource damage can be sought.

That is why the *Wind Spirit* incident in VINP is important: there were laws against such damage in the park and witnesses to the alleged violation. The October 1988 *Wind Spirit* damage could have gone unnoticed. VINP officials recognize the need for antianchor patrols, but the small staff of rangers is increasingly occupied fighting rising drug traffic through the park, rather than monitoring cruise ships.

However, a VINP biologist who happened to be out in his boat was hailed by St. John residents ashore on high ground. They had seen an underwater cloud of sediment kicked up by the *Wind Spirit*'s anchor and chain, Rogers says.

One resident had taken photographs of the incident. Later, divers found a scar roughly 128 meters long and 2 to 3 meters wide.

The *Wind Spirit* incident "made it clear we were not adequately addressing the greatest threat to the marine resources in the park, the destruction by cruise ship anchors," Rogers says. Park Service divers later documented damage by other ships.

The park superintendent restricted anchoring in the park to ships under 225 feet long. Boats 150 feet to 225 feet in length can anchor only in Francis Bay on the north shore of St. John, where the water is deeper and much of the bottom is mud or sand. And some long-devastated areas near shore were declared off limits to all boats so that shallow coral and seagrass communities can recover.

On 24 October 1990—two years after the incident—the US government filed suit against Windstar Cruises, the cruise ship operator. The suit claims the cruise line and *Wind Spirit* captain Thomas A. Strom were "careless, incompetent, negligent and/or inattentive to their duties" when the ship's anchor damaged the reef, which is, in essence, park property. The suit, which at press time was pending in US District Court in St. Thomas, seeks $350,000 in damages for "destroying, disturbing, and damaging coral, marine invertebrates, plants, soil, and rock" in the park when the anchor was "grounded and dragged across a known and charted coral reef."

The company declined to comment on the charges because the court case was pending. It did point out that Richard Maeder, then superintendent of the park, had been aboard the *Wind Spirit* when the anchor was dropped.

Despite the new restrictions, some large-sized cruise ships have continued to anchor illegally within the boundaries of VINP, park officials say. Others anchor over reefs off the nearby British Virgin Islands instead.

A representative of the cruise ship industry says he was unaware that anchors and chains caused any problems in the Caribbean. Jack Estes, president of the International Council of Cruise Lines, the Washington-based operations arm of the industry, says his group is willing to "work with anybody" to solve any such problems.

"Clearly, the Caribbean is a magnificent place," Estes says. "We have to preserve it. It's not only in our interests to do it, but it's also the right thing to do."

Some scientists remain skeptical that the industry was unaware that its anchors were damaging reefs in and out of marine parks and reserves. For example, officials at VINP say the superintendent had written several times to various cruise lines to communicate their concerns about marine resource damage.

The threat of increased recreational use

The rise of cruise ship anchor damage occurs against a backdrop of other escalating pressures on marine resources. If VINP is a microcosm of what is happening to those resources throughout the Caribbean, the outlook for natural systems is grim. A dramatic rise in overall recreational use is directly degrading the park's reefs and seagrass beds, Rogers says.

"I'm not going to say all the reefs are dying," she says. "Some are doing fine. But there's no doubt that the pressures on coral reefs are increasing."

VINP, established in 1956, comprises approximately 56%, or 2816 hectares, of the island of St. John. In 1962, the US government added another 2287 hectares of surrounding waters to the park "to preserve for the benefit of the public significant coral gardens, marine life, and seascapes."

And a popular spot it is. Since 1976, the number of people visiting VINP has tripled, now totaling approximately 1 million per year. Many of them come by boat. In the same period, the number of boats using park waters has risen by a factor of four, to approximately 80 per day. Approximately 30,000 boats, most of them small craft, anchor in the park each year.

At Trunk Bay, site of St. John's most popular beach, use increased from fewer than 20,000 in 1966 to approximately 170,000 two decades

later. Many large cruise ships anchor outside the park and carry hundreds of passengers by small launch to the nearby port of Cruz Bay. The park superintendent now routinely gets requests to bring in groups of 800 people to spend a day at the beach.

"Dramatic increases in the number of people visiting the park have led to congestion and crowding of some beaches, conflicts between the different groups using the park (such as boaters and fishermen), breakage of corals by inexperienced snorkelers, and severe destruction from boats and ships running aground on shallow coral reefs and anchoring on seagrass beds and reefs," Rogers says.

Recreational use is not the only stress on VINP. Storms, including Hurricane Hugo in September 1989, and coral disease have taken a toll on seagrass and coral. Many reefs in the Caribbean are bleaching—a process that can lead to coral death (*BioScience* 41: 77). Bleaching may be related to rising water temperature, which some scientists believe is the result of global warming.

Periodic oil spills and cleanups have taken their toll on the reefs. And although spearfishing and gill netting are banned in the park, fishing with traps, hand lines, and certain kinds of nets is allowed. Studies have shown that reef fishes, conches, and lobsters have been overharvested, Rogers says.

An even more serious threat is "the accelerating pace of coastal and upland development," she says. "Private lands within and outside the park boundary are being cleared and bulldozed to make way for condominiums, hotels, and home sites. Erosion and runoff or sediment from these sites can result in reduction of light available for photosynthesis by marine organisms and smothering of corals and other organisms."

The park has little control over such development activities. "All of these human assaults are superimposed on the natural phenomena that we don't fully understand yet," Rogers says.

The search for data

Beginning in 1983, the National Park Service funded several baseline studies of the VINP marine systems, including seagrass beds, coral reefs, and reef fishes. The studies were conducted by the Virgin Islands Resource Management Cooperative, a group of researchers from the Park Service and 15 other agencies and institutions in the US and British Virgin Islands and Puerto Rico. The studies were aimed at gathering information needed to better manage the parks' natural resources. They documented causes for concern over the rising level of tourism and its environmental consequences.

The marine life in the park depends on the health of its reefs, seagrass beds, and mangroves. Such fish as snappers and grunts migrate daily from the shelter of reefs to feed on nearby seagrass beds at night. These habitats also support threatened turtles and depleted populations of queen conch.

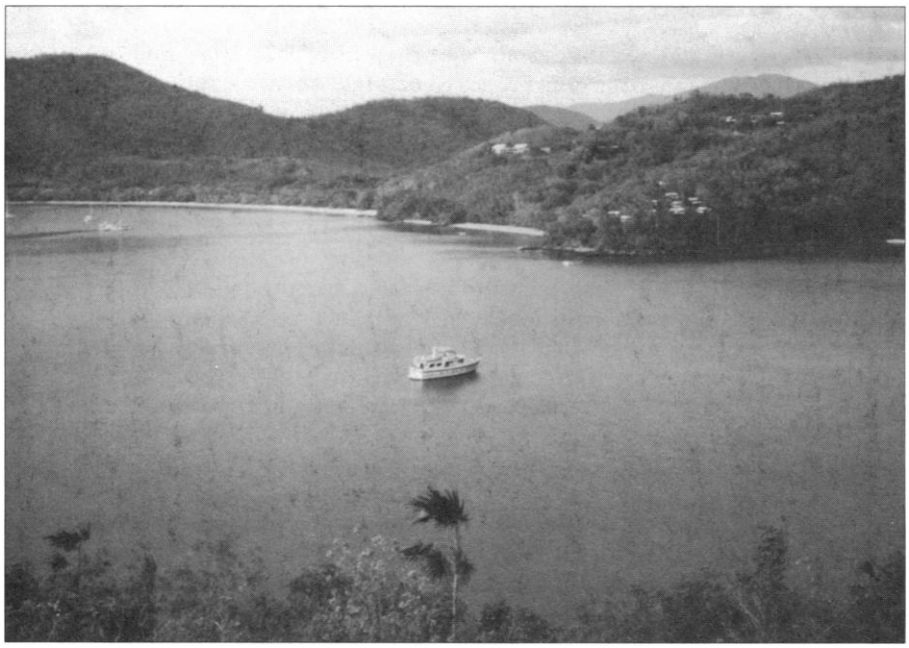
Rogers and her colleagues monitored two of the hardest-hit regions in the park in 1986 and 1987—in Hawksnest Bay and off Windswept Reef. Both are on the northern shore of St. John.

Acknowledging that it was often difficult to distinguish between human damage and damage from such natural forces as heavy swells and coral diseases, the researchers nonetheless were able to determine by watching that boats and snorkelers broke much coral. On some coral colonies, they even observed blue or red paint from boat bottoms.

In another study, the researchers surveyed, from January to March 1987, boats that anchored in waters in the northern parts of the park. The average length of the boats was 45 feet, and 46% of them anchored in coral or seagrass. The bottom was "severely disrupted" 23% of the time that anchors were dropped.

The focus was on small boats because until the mid-1980s only a few larger ships regularly visited and anchored in the park. Most of these, commonly called mini-cruise ships, were between 150 and 225 feet long.

"We gradually became aware that anchors of these [mini-cruise] boats were damaging coral communities in several bays," Rogers says. "The pro-



Francis Bay, St. John, US Virgin Islands. Photo: William H. Allen.

liferation of these cruise ships in the last five or six years raised concern because they are capable of entering very shallow, environmentally sensitive areas that are inaccessible to larger vessels."

It is impossible to determine how much reef damage has occurred in the park and who or what is responsible. Most incidents are not detected, many of the reefs are deep, and some are uncharted. Aerial photos can reveal reefs only to approximately 18 meters in depth, and even then they do not show the reef condition.

When reef damage is discovered, biologists often cannot be sure the damage had natural or human causes. And underwater surveys of such damage are difficult in shallow waters and impossible at the greater depths where the anchors of many large cruise ships reach reefs. "In spite of these drawbacks, we know that anchors have caused and continue to cause unacceptable levels of destruction, destruction which is superimposed on that from all other causes," Rogers says.

The outlook for solutions

The dilemma faced by managers of marine national parks is to find ways that rising numbers of people can continue to enjoy the region's natural resources without harming the fragile ecosystems that the park was set up to protect. The same is true elsewhere in the Caribbean, where protected areas do not exist but where marine-based tourism is being sought as a way to attract revenue.

At VINP and national parks in the Florida Keys, managers have taken several steps to minimize damage. Other than research on the parks' marine resources and restrictions on anchoring, the major steps include moorings and environmental education.

The best solution to the anchor damage problem is to provide alternatives such as permanent moorings and to require that boats do not drop anchor, Smith says. Boat moorings have been used successfully in the Looe Key and Key Largo national marine sanctuaries, as well as other marine parks and monuments in Florida.

Where no moorings exist, vessels should be required to remain under power or anchor only in sand. Another alternative, especially applicable to boats that cater to scuba divers, is to have a diver hand-place the anchor to reduce reef damage.

"We've installed mooring buoys at the popular reefs [in Florida]," says marine biologist Causey. "And there's been some heightened awareness on the part of the public as to the need to anchor in sand."

VINP officials also have begun to install mooring buoys for small boats, but since visitors to the Virgin Islands use many, less well-defined areas scattered throughout the park for sailing, snorkeling, or scuba diving, park officials worry about the cost and practicality of covering all the necessary sites with a sufficient number of moorings. They have installed a large number of near-shore marker buoys to warn boats away from seagrass beds and coral communities.

Outside of major Caribbean harbors, moorings that can handle mini-cruise ships, much less large cruise ships, have not come into widespread use. Part of the problem is that they are expensive, requiring more and heavier hardware than moorings for small craft. And the chains that come with such moorings can still cause major damage to the bottom, says Smith.

Another possible solution to the anchor-damage problem may be offered by new technology—the Global Positioning System (GPS), a satellite-based navigational system that can accurately calculate a ship's position to within a few meters. Cruise ship captains could use GPS to anchor at particular spots that park managers have determined to be devoid of reefs, Rogers says. The cost of such a system is within reach of the owners of many smaller vessels as well.

Scientists believe that public education can go a long way toward relieving stress on marine ecosystems, primarily by informing people about the environment and how human activities alter it. "The marine environment is only a little less familiar to many people than outer space," Rogers says. "It is very difficult to get people to care about something they never see, like a coral reef in 90 feet of water."

The national parks publish mooring and anchoring guides and brochures that describe marine natural resources. They employ environmental educators who visit local schools and talk to visitors at park facilities. At VINP, popular beaches have signs that ask for help in protecting reefs and show a snorkeler's fin breaking coral. A videotape describing the park's natural and cultural resources is shown aboard cruise ships and in the park's new visitors' center at the passenger-unloading point in Cruz Bay.

Such education is "really important," Rogers says. "Most people don't want to intentionally destroy a marine ecosystem. Some of [the damage] is pure, blind greed. But some of it is ignorance."

Management of the ever-changing interface between marine resources and marine-based tourism is an ongoing process. It requires constant adjustment and communication, Rogers says.

It also requires that managers have reliable, objective information to make their decisions on balancing public use and ecosystem abuse. It follows that such information should comprise both biological data and data on recreational use. The managers will have to weigh a variety of competing interests and accept the fact that a decision must be made in the absence of all necessary information. "If any errors are made, they should be on the side of resource protection," Rogers says. "Restrictions on visitation or use can always be relaxed if warranted. It is difficult to revive a dead reef." ❑

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